

THE INVENTION CLAIMED IS

1. A high-gain preamplifier based on optical parametric amplification, comprising:
  - a first nonlinear crystal;
  - a second nonlinear crystal operatively connected to said first nonlinear crystal;
  - a first beam relay telescope operatively connected to said first nonlinear crystal and said second nonlinear crystal;
  - a second beam relay telescope operatively connected to said first nonlinear crystal, said second nonlinear crystal, and said first beam relay telescope;
  - a first harmonic beamsplitter operatively connected to said first nonlinear crystal, said second nonlinear crystal, said first beam relay telescope, and said second beam relay telescope; and
  - a second harmonic beamsplitter operatively connected to said first nonlinear crystal, said second nonlinear crystal, said first beam relay telescope, said second beam relay telescope, and said second harmonic beamsplitter.

2. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein said first nonlinear crystal and said second nonlinear crystal are independently angle tuned to achieve an angular phase-matching condition.

3. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein said first nonlinear crystal and said second nonlinear crystal are cut for second harmonic generation of 1064 nm ( $\theta=22.8^\circ$ , ( $\phi=0^\circ$ )).

4. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein said first nonlinear crystal and said second nonlinear crystal have output faces with a  $2^\circ$  wedge on said output faces.

5. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein said first nonlinear crystal and said second nonlinear crystal are arranged to achieve walk-off compensation.

6. The high-gain preamplifier based on optical parametric amplification of claim 5, wherein said first nonlinear crystal has an input face and said first nonlinear crystal and said second nonlinear crystal are misaligned in the direction of the walk-off on the input face of said first nonlinear crystal.

7. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein the size of said first nonlinear crystal and said second nonlinear crystal is  $4\times 4\times 15$  mm $^3$ .

8. The high-gain preamplifier based on optical parametric amplification of claim 1, wherein said first harmonic beamsplitter and said second harmonic beamsplitter are highly reflective for 1054 nm at s-polarization, and highly transmissive for 532 nm wavelength, at p-polarization.

9. The high-gain preamplifier based on optical parametric amplification of claim 1, including a seed beam imaged from a seed source operatively connected to said first nonlinear crystal, said second nonlinear crystal.

10. A high-gain preamplifier based on optical parametric amplification, comprising:

first nonlinear crystal means for amplification of a signal pulse by transfer of energy from a pump pulse though difference-frequency generation;

second nonlinear crystal means for additional amplification of said signal pulse by transfer of energy from said pump pulse though difference-frequency generation, operatively connected to said first nonlinear crystal;

first beam relay telescope means for relay imaging the pump transverse intensity profile, adjusting the pump beam diameter, and collimating the pump beam, operatively connected to said first nonlinear crystal means and said second nonlinear crystal means;

second beam relay telescope means for relay imaging the seed transverse intensity profile, adjusting the seed beam diameter, and collimating the seed beam, operatively connected to said first nonlinear crystal means, said second nonlinear crystal means, and said first beam relay telescope means;

first harmonic beamsplitter means for nearly collinear coupling of the seed beam with the pump beam into the first nonlinear crystal, operatively connected to said first nonlinear crystal means, said second nonlinear crystal means, said

first beam relay telescope means, and said second beam relay telescope means;

and

second harmonic beamsplitter means for separating the amplified signal and idler beams from the residual pump after amplification in the second nonlinear crystal; operatively connected to said first nonlinear crystal means, said second nonlinear crystal means, said first beam relay telescope means, said second beam relay telescope means, and said second harmonic beamsplitter means.

11. A high-gain preamplifier based on optical parametric amplification, comprising:

a first beta-barium borate (BBO) crystal;

a second beta-barium borate (BBO) crystal operatively connected to said first beta-barium borate (BBO) crystal;

a first beam relay telescope operatively connected to said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal;

a second beam relay telescope operatively connected to said first beta-barium borate (BBO) crystal, said second beta-barium borate (BBO) crystal, and said first beam relay telescope;

a first harmonic beamsplitter operatively connected to said first beta-barium borate (BBO) crystal, said second beta-barium borate (BBO) crystal, said first beam relay telescope, and said second beam relay telescope; and

a second harmonic beamsplitter operatively connected to said first beta-barium borate (BBO) crystal, said second beta-barium borate (BBO) crystal, said first beam relay telescope, said second beam relay telescope, and said second harmonic beamsplitter.

12. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal are independently angle tuned to achieve an angular phase-matching condition.

13. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal are cut for second harmonic generation of 1064 nm ( $\theta=22.8^\circ$ ,  $(\phi=0^\circ)$ ).

14. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal have output faces with a  $2^\circ$  wedge on said output faces.

15. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal are arranged to achieve walk-off compensation.

16. The high-gain preamplifier based on optical parametric amplification of claim 15, wherein said first beta-barium borate (BBO) crystal has an input face and said first beta-barium borate (BBO) crystal and said second beta-barium

borate (BBO) crystal are misaligned in the direction of the walk-off on the input face of said first beta-barium borate (BBO) crystal.

17. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein the size of said first beta-barium borate (BBO) crystal and said second beta-barium borate (BBO) crystal is 4x4x15 mm<sup>3</sup>.

18. The high-gain preamplifier based on optical parametric amplification of claim 11, wherein said first harmonic beamsplitter and said second harmonic beamsplitter are highly reflective for 1054 nm at s-polarization, and highly transmissive for 532 nm wavelength, at p-polarization.

19. The high-gain preamplifier based on optical parametric amplification of claim 11, including a seed beam imaged from a seed source operatively connected to said first beta-barium borate (BBO) crystal, said second beta-barium borate (BBO) crystal.

20. A method of high-gain preamplifier based on optical parametric amplification, comprising the steps of:

using a first nonlinear crystal to provide amplification of a signal pulse by transfer of energy from a pump pulse though difference-frequency generation;

using a second nonlinear crystal to provide additional amplification of the signal pulse by transfer of energy from the pump pulse though difference-frequency generation;

using a first beam relay telescope to relay the pump transverse intensity profile, adjust the pump beam diameter, and collimate the pump beam;

using a second beam relay telescope to relay the seed transverse intensity profile, adjust the seed beam diameter, and collimate the seed beam;

using a first harmonic beamsplitter for collinear coupling of the seed beam with the pump beam into the first nonlinear crystal; and

using a second harmonic beamsplitter for separating the amplified signal and idler beams from the residual pump after amplification in the second nonlinear crystal.